3D Relativistic Magnetohydrodynamic Simulations of Current-Driven Instability. I. Instability of a static column

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ABSTRACT

We have investigated the development of current-driven (CD) kink instability through three-dimensional relativistic MHD simulations. A static force-free equilibrium helical magnetic configuration is considered in order to study the influence of the initial configuration on the linear and nonlinear evolution of the instability. We found that the initial configuration is strongly distorted but not disrupted by the kink instability. The instability develops as predicted by linear theory. In the non-linear regime the kink amplitude continues to increase up to the terminal simulation time, albeit at different rates, for all but one simulation. The growth rate and nonlinear evolution of the CD kink instability depends moderately on the density profile and strongly on the magnetic pitch profile. The growth rate of the kink mode is reduced in the linear regime by an increase in the magnetic pitch with radius and the non-linear regime is reached at a later time than for constant helical pitch. On the other hand, the growth rate of the kink mode is increased in the linear regime by a decrease in the magnetic pitch with radius and reaches the non-linear regime sooner than the case with constant magnetic pitch. Kink amplitude growth in the non-linear regime for decreasing magnetic pitch leads to a slender helically twisted column wrapped by magnetic field. On the other hand, kink amplitude growth in the non-linear regime nearly ceases for increasing magnetic pitch.

Subject headings: instabilities - MHD - methods: numerical - galaxies: jets

1. Introduction

Relativistic jets occur in active galactic nuclei (**AGN**) (e.g., Urry & Padovani 1995; Ferrari 1998; Meier et al. 2001), occur in microquasars (e.g., Mirabel & Rodriguez 1999), and are thought responsible for the gamma-ray bursts (**GRB**) (e.g., Zhang & Mészáros 2004; Piran 2005; Mészáros

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